

OBSERVATIONS ON THE RÔLE OF COCKROACHES IN DISEASE

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As the cause of disease and as possible carriers of pathogenic organisms cockroaches have received less attention than other domestic pests, and less than might have been expected considering their wide distribution, their abundance, especially in tropical countries, their filthy habits and the opportunities they have of contaminating food, and the almost universal loathing with which they are regarded.

It is generally admitted that they are eminently fitted to be disseminators of infections, and from time to time they have come under suspicion as such, but hitherto no definite charge appears to have been brought home against them. There is, however, some experimental evidence that certain pathogenic organisms may be transported by them or may pass through their intestines. Morrell (1911), for example, as the result of his experiments, concluded that the insects are able by contamination with their faeces to bring about the souring of milk, to infect food and milk with intestinal bacilli, to transmit the tubercle bacillus, to disseminate pathogenic staphylococci, and to transmit from place to place destructive moulds. Longfellow (1913) showed that they may carry on their legs *Bacillus coli communis*, *B. proteus vulgaris*, *Staphylococcus aureus*, *S. citreus*, and a bacillus of the *subtilis* type, and found the same organisms in their faeces. He, therefore, considered that, as possible carriers of infection, it is almost as important to prevent the multiplication of cockroaches as of house-flies. This view, however, may be somewhat exaggerated, since Herms (1915) has pointed out that the feet of cockroaches are less well provided with spines and hairs than those of the house-fly, and are, therefore, less well adapted to the collection of filth. Barber (1912), working in Manila, has shown that cockroaches may be infected with plague bacilli, and more

recently (1914), that when fed on cultures or samples of human faeces containing cholera vibrios these organisms multiply in their intestines and are discharged in the faeces without losing their virulence. The cockroaches (*P. americana*) themselves are apparently unaffected, and Barber concludes that they may act as carriers of cholera to human food. According to Fibiger (1913), cockroaches (*P. orientalis* and *P. americana*) are also the intermediate hosts of a nematode (*Filaria* sp.) which causes malignant tumours in rats which feed upon them; and Wellman (1910) has suggested that a tapeworm (*Davainea* sp.) may be disseminated by these insects. As supplementing these examples, which are by no means complete, the following notes on a few experiments carried out at Accra may be of interest.

The species of cockroach employed in the experiments was *Periplaneta americana*, L. The insects were kept singly, in wide-mouthed glass jars, which were changed daily, and were fed on moist bread. Before submitting them to any experimental test, their faeces were examined carefully for several consecutive days in order to determine what natural infections they harboured. In the majority of the experiments, the material (faeces, etc.) which it was desired a cockroach should eat was offered to it smeared on bread. As soon as it had been consumed, the cockroach was transferred to a clean, dry jar and fed on moist bread, each pellet of faeces passed subsequently being examined during the following week, or longer period. In some experiments with bacteria, however, when it was necessary to prevent contamination of the limbs, etc., the cockroach was immobilised in a groove in a piece of cork (somewhat resembling a setting-board for lepidoptera) fixed by a layer of paraffin to a glass plate. In this manner the cockroach could be fed at the one end, and its faeces collected at the other without risk of contamination of the faecal pellets by the material used for feeding. The addition of a little carmine to the infecting feed was sometimes found to be of assistance as an indicator showing when the material had passed through the intestine.

The cockroaches usually passed one or two faecal pellets each day, which were either solid or semi-solid. Diarrhoea and the passage of liquid faeces was, however, by no means rare, and the insects were also liable to become constipated under the

conditions of the experiments. When forming their egg-capsules they frequently passed no faeces for several days in succession.

The faeces of the cockroaches always, or almost always contained innumerable bacteria of various types, yeast cells, moulds, fungal hyphae, &c., and in recently captured insects often also a considerable quantity of grit. After being in captivity for some days the number of yeast and fungal cells usually increased, and the bacteria became more numerous. A number of other parasites or coprozoic organisms were noted during the experiments. Perhaps the most common was a ciliate resembling *Balantidium blattarum*, Ghosh, the cysts of which were present in the majority of the cockroaches examined. *Oxyuris blattae* was frequently present, and in a few individuals were found *Entamoeba blattarum*, *Gregarina blattarum*, and a species of spirochaete. Mites,* sometimes still alive, were found in the faeces on a few occasions. Thirty cockroaches were especially examined immediately after capture for eggs of worms known to frequent the intestine of man: in one a single egg indistinguishable from that of *Trichuris trichiura* was found. It should be stated, however, that most of the cockroaches were collected in the laboratory, where they would have little or no opportunity of feeding on human excrement.

TUBERCLE BACILLUS

Morrell (1911) has demonstrated that tubercle bacilli may be found in the faeces of cockroaches which have fed on infected sputum. In confirmation of this observation, three experiments were carried out in collaboration with Dr. A. Ingram and Dr. J. F. Corson.

The cockroaches, whose faeces had been previously examined and found to be free from acid-fast bacilli, were given sputum containing numerous tubercle bacilli from a case of phthisis in an African. They consumed the sputum very readily. Every sample of faeces passed subsequently, some of them fluid or semi-solid, was examined for *B. tuberculosis*, with the following results. The faeces passed on the first day after the infecting feed were free from the bacilli, those passed on the second day to the fourth or fifth day

* These mites have been examined by Mr. S. Hirst, of the British Museum, who has kindly informed me that they are larvae of a Tarsonemid.

contained tubercle bacilli, and after this, up to the fourteenth day, when examinations were stopped, no more tubercle bacilli were detected.

The tubercle bacilli found in the faeces of the cockroaches stained in a normal manner and looked healthy. That they were actually living and virulent was proved by emulsifying one faecal pellet with normal saline solution and inoculating it into the groin of a guinea-pig, which in due course became infected with tuberculosis.

Cockroaches then feed readily on human sputum, and if the sputum contains tubercle bacilli, pass these organisms in their faeces for several days in a living and virulent condition. They do not appear to become infected with the bacilli themselves.

LEPROSY BACILLUS

In two similar experiments, cockroaches were given scrapings from the nose of a leper which contained numerous *B. leprae*. It was found that these bacilli also passed through the intestine of the insects, and appeared in the faeces for a day or two after the infecting feed. So far as could be judged from the appearance of the bacilli and from their staining properties, they had not been injuriously affected.

TYPHOID AND DYSENTERY BACILLI

It has been suggested by Scott (1915) that cockroaches may have acted as mechanical carriers of the infection in an outbreak of typhoid fever in Jamaica, and on other occasions elsewhere these insects have come under suspicion during epidemics of this disease and of bacillary dysentery. Cockroaches might also spread such infections by intestinal contamination. In order to determine if such bacilli, still living, could pass through their intestine, two experiments each were carried out with *Bacillus typhosus*, *B. paratyphosus*, B., and *B. dysenteriae* (Flexner Y).

The cockroaches used in the experiments had been previously tested carefully to see if their faeces contained any organisms resembling bacilli of the typhoid-dysentery group and had been found to be free from such infections. They were immobilised in a groove in a piece of cork with only their heads and tails projecting,

and were fed with small pieces of bread soaked with recent cultures of the bacilli to be tested. Their faeces were tested (in the routine manner) for the bacilli during the following week or ten days, but in none of the six experiments were they recovered.

These experiments, so far as they go, do not support the view that *B. typhosus*, *B. para-typhosus*, *B.*, and *B. dysenteriae* (Flexner Y) can pass unscathed through the intestine of the cockroach, but their number was too small to be conclusive. The faeces of the cockroaches contained a dense and varied bacterial and fungal flora, which may very well have out-grown the more delicate bacilli.

GONORRHOEA

In one experiment Gonococci were fed to a cockroach, and were subsequently sought for in its faeces. None were found either in direct smears or in cultures.

ENTAMOEBA HISTOLYTICA AND *E. COLI*

The cockroaches used in these experiments had previously been carefully examined for amoebic infections, a precaution which was doubly necessary, because some of these insects at Accra had been found naturally infected.

In four experiments cockroaches were given blood and mucous containing numerous actively motile *E. histolytica* from the stools of African patients suffering from acute dysentery. They consumed the samples readily, but neither amoebae nor their cysts were found in their faeces during the following week.

In nine experiments each human faeces containing cysts of *E. histolytica* and *E. coli* were fed to cockroaches. In seven of the former experiments cysts of *E. histolytica* were found in the faeces, and in seven of the latter experiments cysts of *E. coli*. The cysts were observed in the faeces usually for only one to three days, and eventually disappeared completely: they appeared to be healthy and unharmed by their passage through the cockroaches. No amoebae were found.

It would seem, therefore, that cysts of *E. histolytica* and *E. coli* can pass through the intestine of cockroaches without injury, and may thus be disseminated by these insects, but that they do not produce an actual infection in these hosts.

ENTAMOEBEA OF A MONKEY

In another experiment entamoebae resembling *E. coli* from the faeces of a monkey (*Cercopithecus patas patas*) were given, but no entamoebae or cysts were subsequently found in the faeces of the cockroach. A few days later the faeces of the same monkey, which now showed numerous eight-nucleated and a few sixteen-nucleated cysts, were fed again to the same cockroach. On the following day no faeces were passed by this cockroach, but on the second and third days its faeces contained numerous cysts, similar to those in the monkey's faeces, which appeared to be healthy and were not stained by eosin. On the fourth day the cysts were fewer, and on subsequent days none were found.

GIARDIA

In two experiments cysts of *Giardia intestinalis* fed to cockroaches in human faeces passed through their intestines apparently unharmed and unchanged.

EGGS OF WORMS

A number of experiments were carried out to determine what was the effect on the eggs of worms of passage through the intestine of cockroaches. The eggs were given in human faeces smeared on bread. The results of the experiments may be summarised as follows.

Hook-worms. Seven experiments. The eggs of *Ancylostoma duodenale* and *Necator americanus* passed through the intestine unharmed, and appeared in the faeces for from one to three days after the infecting feed, the time depending on the rate of passage of the intestinal contents, which was variable. They had undergone some development, many of those found in the cockroaches' faeces containing living embryos, which subsequently hatched when the faeces, with a little saline solution, were mixed with charcoal and kept at the laboratory temperature. It may be added here that other experiments showed that eggs of *Ancylostoma ceylanicum* in dogs' faeces fared similarly when fed to cockroaches.

Ascaris. Five experiments. The eggs of *Ascaris lumbricoides* passed through the intestine and appeared in the faeces of the cockroaches for a day or two. They appeared to be unharmed. In most cases they also were unchanged, but in one experiment, in

which they did not appear in the faeces until the fourth day owing to the fact that the cockroach was constipated, they had undergone slight development, their contents having divided.

Trichuris. Eight experiments. The eggs of *Trichuris trichiura* passed through the intestine with the residue of the infecting feed, and appeared in the faeces apparently unharmed and usually unchanged, but sometimes having undergone slight development, their contents having divided. Eggs were occasionally found also a day or two later, and in this case they were usually empty shells. For example, a cockroach fed with human faeces containing *Trichuris* eggs showed in its faeces on the following day numerous healthy-looking, unsegmented eggs, on the next day a single, healthy-looking, unsegmented egg, on the third and fourth days no eggs, but on the fifth day two empty shells.

Taenia. Four experiments. The eggs of *Taenia saginata* used appeared in the faeces of the cockroaches apparently unchanged in two of the experiments, in one only shrunken eggs were observed, and in the fourth none were found. The eggs were scanty in the sample of human faeces used in these experiments.

Bilharzia. No opportunity has occurred of experimenting with the eggs of *Schistosoma mansoni*. In one experiment, however, urinary deposit containing numerous eggs of *S. haematobium* was fed to a cockroach on bread. The eggs, apparently unchanged, appeared in the faeces of the insect on the following day.

From these experiments it is clear that the eggs of many intestinal worms may pass unharmed through cockroaches, and as these insects readily feed on human faeces they may aid in the dissemination of these parasites. In some cases the initial stages of development took place in the eggs during their sojourn in the cockroaches.

APHIOCHAETA XANTHINA

The larvae of the small fly *Aphiochaeta xanthina*, Speiser, which belongs to the Family *Phoridae*, are known to cause intestinal myiasis in man in the Gold Coast, it being supposed (Patton, 1922) that 'its eggs and larvae probably gain entrance to the human alimentary tract in food, and particularly in stale meat.' In a single experiment eggs of this fly were given to a cockroach on moist

bread, and were eaten by it. On the second and third days following the experimental feeding the faecal pellets passed by the cockroach were found to contain fragments of the eggs and one or two almost complete eggs which appeared to be empty. Thereafter, up to the fourteenth day, when examinations were discontinued, no evidence was found of the presence of the fly in any stage of its development.

SUMMARY

The following organisms appeared to pass unharmed through the intestine of the cockroach *Periplaneta americana*:—*Bacillus tuberculosis*, *B. leprae*, cysts of *Entamoeba histolytica*, *E. coli* and of an entamoeba of a monkey resembling *E. coli*, cysts of *Giardia intestinalis*, and eggs of *Ancylostoma duodenale*, *A. ceylanicum*, *Necator americanus*, *Ascaris lumbricoides*, *Trichuris trichiura*, *Taenia saginata*, and *Schistosoma haematobium*.

On the other hand Gonococci, *Entamoeba histolytica*, *E. coli*, and an entamoeba of a monkey resembling *E. coli* (in the vegetative stages), eggs of *Aphiochaeta xanthina*, and, in two experiments each, *Bacillus typhosus*, *B. para-typhosus*, *B.*, and *B. dysenteriac* (Flexner Y) were not recovered in the faeces of cockroaches after experimental feeding.

No evidence was obtained that any of the organisms used in the experiments established themselves as parasites in the intestine of the cockroaches.

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